Plug-in Hybrid Vehicle Optimization Using Vehicle-to-Cloud Connectivity

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Project ID: eems071

macchina

Overview

Timeline

- Project Start Date: 7/1/2018
- Project End Date: 6/30/2019
- Percent Complete: 95%

Budget

- Total Project funding: $150k
  - DOE Share: $150k
  - Contractor Share: $0k
- Funding for FY 2017: N/A
- Funding for FY 2018: ~$50k
- Funding for FY 2019: ~$100k

Barriers

Barriers Addressed:

- Consumers of plug-in hybrid electric vehicles (PHEVs) have desire to maximize electric only operating range
- Large high-resolution datasets from vehicles currently not used to reduce energy consumption

Partners

Relevance/Objectives

- Key Goal:

  Extend electric only operating (EOO) range, and therefore improve fuel economy by using a cloud-connected intelligent energy management strategy (EMS) as an aftermarket solution for PHEV owners

- Specific Objectives (Phase 1 STTR):
  1. Design prototype vehicle communication device (VCD)
     - Collect necessary vehicle data
     - Enable EV mode in one PHEV remotely
  2. Determine the technical feasibility and robustness of the hardware
  3. Quantify potential vehicle fuel economy improvements through computer simulation of a chosen PHEV

Milestones

Date	Task	Status
Dec 18	Choose the vehicle on which to demonstrate the developed technology and study its operation	Complete
Mar 19	Design and configure the VCD that will form the basis for the project	Complete
Apr 19	Demonstrate that the VCD hardware is suitable for use the envisioned application	Complete
Jun 19	Determine the feasibility of using VPRO technology to extend the EOO of light-duty PHEVs	95%

Approach

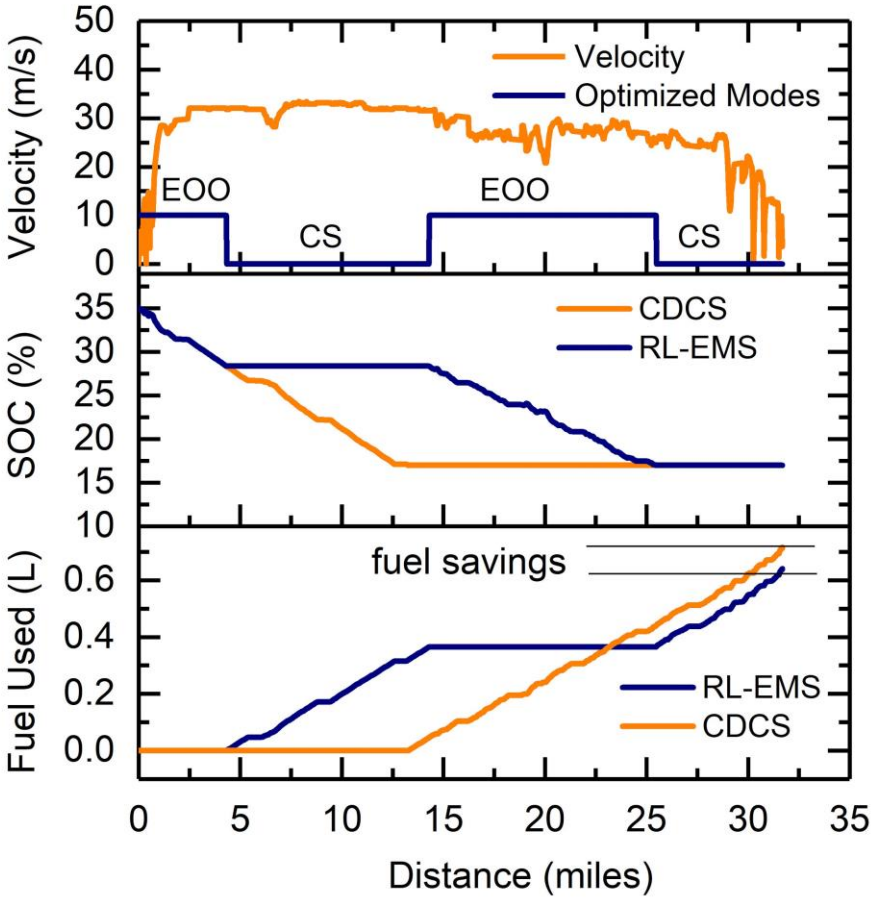
STTR Phase 1: Demonstrate feasibility of aftermarket VCD and cloud-based energy management strategy

1. Develop prototype VCD
2. Realize vehicle interface and data logging capability including GPS and communications
3. Chevy Volt PHEV chosen to demonstrate hardware and EMS
4. Simulated commuting route selected and driven to prove MPGe improvement

Technical Accomplishments

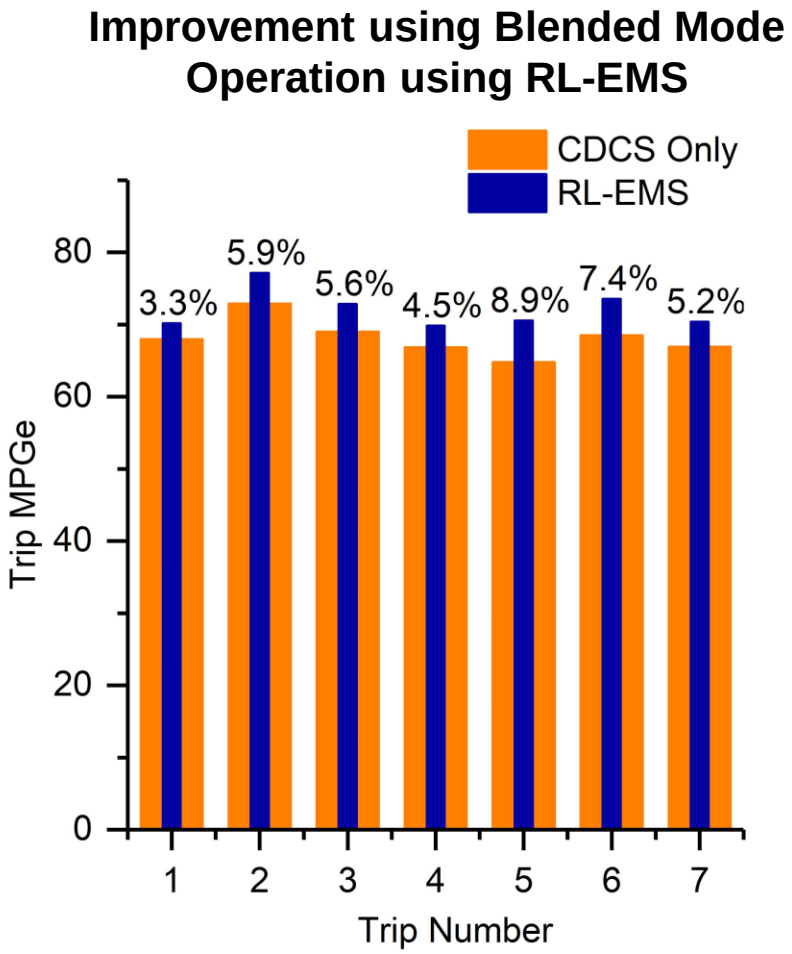
- Data collected from Chevy Volt on 20.6 mile simulated commuting route using VCD
- Low-order vehicle model: estimate charge sustaining vs. EOO operation fuel consumption and energy use
  - Volt “hold” vs. “normal” mode = CS vs. EOO
  - Similar modes in other PHEVs
- Reinforcement learning algorithm used to determine when to switch modes on test routes (eg. EMS algorithm)

Example Trip
(7.4% MPGe Improvement)



Technical Accomplishments

- RL-EMS tested on seven historical one-way commuting trips
- **MPGe improvement between 3.3 to 8.9%**
- Multi-mode strategy currently being tested in-use on same simulated delivery trip
- App driver interface developed to inform mode selection



Response to Previous Year Reviewers' Comments

This project was not previously reviewed

Collaborators

Partners

- Overall project management, VCD hardware development, vehicle interface and data collection

- Energy management strategy algorithm development, road study of MPGe improvement

Collaborators

David Stout Associates

- Technology and commercialization plan

Eddie Arpin

- Driver vehicle interface and software development

Remaining Challenges and Barriers

- Currently challenging to control factory powertrain operating mode using VCD
  - May opt to inform driver to control mode instead of directly controlling mode
- Test the EMS on in-use routes using real-time data as input
  - Direct, secure communication from VCD to cloud server necessary

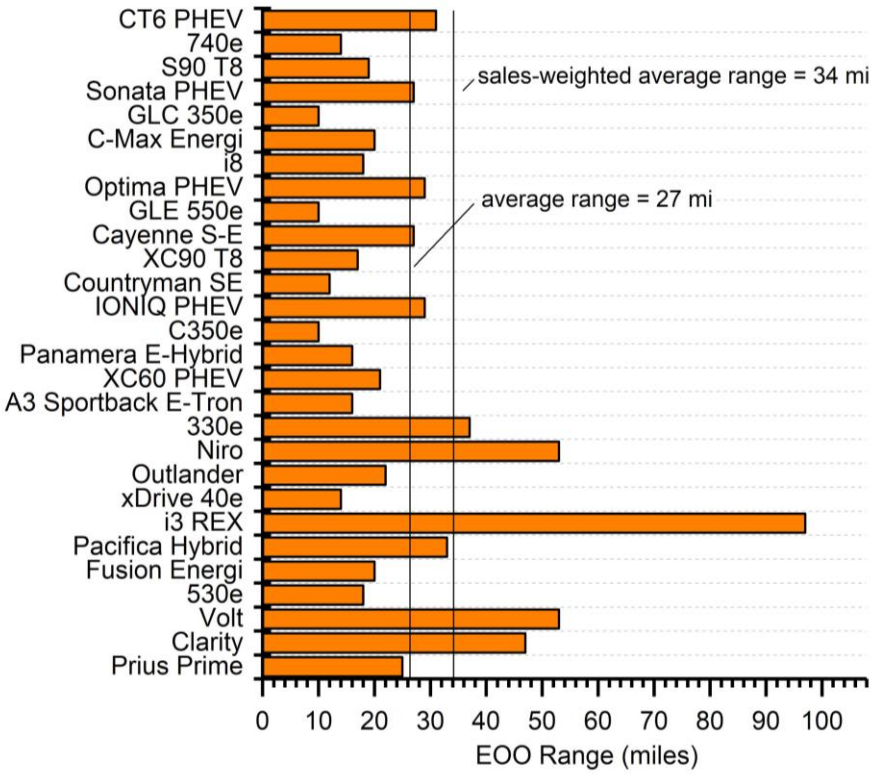
Proposed Future Research

Any proposed future work is subject to change based on funding levels

- Objectives of planned Phase II project:

1. Expand the number of compatible PHEV models
2. Generalize the intelligent EMS developed in Phase I for use with multiple vehicles and demonstrate MPGe improvements
3. Develop a smart-phone app integrated with a routing API that communicates VCD and a developed cloud server
4. Pursue a commercialization strategy that leads to a viable product and service

PHEV Models Available in 2018



Summary

- Phase I project to be completed in FY19
  - VCD developed to interpret and collect necessary vehicle data + GPS from one PHEV
  - Low order model calibrated using vehicle data collected from simulated commuter route
  - RL-EMS algorithm used to simulate blended powertrain mode operation to achieve between 3.3% to 8.9% improvement in MPGe
- Phase II project planned for FY20 to generalize EMS for more PHEVs across range of manufacturers to realize viable aftermarket solution